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UTILIZATION OF BAKAL SIDERITE ORES

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While siderite ores make up about half of the Bakal iron-ore deposits, they have a very limited market. However, they are still important from the standpoint of economy, since their concentrated occurrence permits easy mining. Many of the ore bodies in these deposits are being exploited -- Gayevskaya pit, Verkhne-Bulanskiy, Southern Quarry No 3 of the Mine imeni OGPU, and others.

The following table shows the percentage of carbonate (siderite) and oxidized iron ores in the Bakal deposits, as of 1 January 1948:

Deposits	Percentage	
	Oxidized	Siderite
All deposits	30	70
Lenin	30	70
Mine imeni OGPU	43	57
Western slopes of Mt Irkuskan	30	70
Eastern slopes of Mt Irkuskan	50	50
Shuydinskiy No 1	10	90
Bulandinsk	67	33
Average	50/sic/	50/sic/

Siderite ores are generally finely or moderately granulated and dense. The ratio of siderite to oxidized ores varies from mine to mine, but the amount of oxidized ores decreases to zero at a certain level in all mines.

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Bakal ores contain a large quantity of magnesium carbonate in the form of a solid solution. Consequently, magnesium siderites as a substitution product of dolomitized limestone and dolomites should be classed with sideroplesites and pistomesites.

The average composition of siderite ores is as follows 75 percent  $\text{FeCO}_3$ , 20 percent  $\text{MgCO}_3$ , 2 percent  $\text{CaCO}_3$ , and 2 percent  $\text{MnCO}_3$ , while the composition of pistomesites is 55-65 percent  $\text{FeCO}_3$ , 30-40 percent  $\text{MgCO}_3$ , 2-3 percent  $\text{CaCO}_3$ , and 2 percent  $\text{MnCO}_3$ .

Carbonate ores include the basic carbonate mass and foreign admixtures. Microscopic study of the latter reveals only a small amount of quartz, clay material, and pyrite. Occasionally siderite replaces dolomitized limestones or dolomite in the form of veins and shallow impregnations. The mineralogical composition of siderite is complex and irregular. Rich siderites contain only one mineral, and only the crystalline phase, composed of  $\text{FeCO}_3$  molecules with an isomorphous admixture of magnesium and calcium carbonates and possibly manganese carbonate in the form of a solid solution, is found in their carbonate constituent.

Poor siderites contain from 20 to 25 percent iron, with a high magnesium, alumina, calcium oxide, sulfur, and phosphorus content. They contain two minerals, including in their composition two phases, namely siderite and iron-dolomite.

The following is the phase composition of poor siderite ores:

	Composition (%)			
	(Fe,Mn) $\text{CO}_3$	$\text{MgCO}_3$	$\text{CaCO}_3$	Total
Siderite	55.9	42.0	2.1	100.0
Dolomite	--	65.0	35.0	100.0

Chemical analyses established the presence of small amounts of manganese (above one percent) in Bakal carbonate ores. Manganese replaces bivalent iron in these ores. Siderites are the highest sulfur-containing ores of the Bakal region, and the percentage content varies from thousandths of a percent to one percent and even higher. This is caused by the marked concentration of pyrite or by the presence of barium oxides, which are found in the form of pockets or small veins. It is much easier, however, to contend with the sulfur content than with the phosphorus content, since the sulfur is easily burned off in roasting or agglomeration processes.

Phosphorus usually exists in the form of small needles of apatite or in the form of apatite dust. It is found more rarely in the form of secondary iron phosphates. When the phosphorus occurs in the rocks enclosing the ore body (in clay slates, clays, etc.), it is a mechanical admixture and most of it can be removed easily in elementary dressing operations.

Several methods are suitable for utilization of siderite ores: (1) roasting with subsequent smelting in blast furnaces, (2) addition to the charge in agglomeration of oxidized ores, (3) roasting and magnetic concentration, and (4) smelting of crude ores in blast furnaces.

#### Roasting of Siderite Ores

Siderite iron ores are not very abundant, but have been utilized since ancient times because of their purity and ease of smelting after roasting. On the average (including all known deposits), the raw ore contains about 25-35 percent iron, and, after roasting, the iron content is increased to 45-59 percent. Some of the oldest Soviet metallurgical plants in the northern part of the Gor'kiy

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region (Klimkovskiy, Peskovka, Kirs, and Omutninsk plants) have been processing calcined clay siderites and sphaerosiderites with iron content of 30-32 percent. The iron content is increased to 36-40 percent after roasting. Although Bakal ores are much richer than Omutninsk ores, they nevertheless have to be roasted or agglomerated to remove sulfur and volatile substances. Roasting yields a lumpy, easily smelted, porous material of great metallurgical value.

#### Dressing of Poor Siderite Ores

About 30 percent of the Bakal siderite deposits are low-grade ores (iron content, 20-30 percent). The main ore minerals, namely siderite, sideroplesite, and pistomesite, are generally mixed with dolomites, ankerites, or some other type of rock. The poorest of the low-grade ores must be concentrated. Experiments have shown that surface roasting is sufficient to give magnetic properties to siderite grains; thus, even under conditions of agglomeration roasting, the magnetization of siderite progresses rapidly and strongly.

#### Agglomeration of Carbonate Ores

During World War II an agglomeration plant was built at Bakal. This plant supplied the Chelvybinsk Metallurgical Plant with powdery ores, as well as washed clayey ores, and siftings which were not suitable for direct smelting in blast furnaces. Such ores, together with clayey ores, comprise about 30-40 percent of the total resources of some enterprises -- e. g., the Mine imeni OGPU.

Research conducted by Mekhanobr revealed that the best agglomerate is obtained when carbonate iron ores are added to the agglomerate charge. This addition improves the caking of the powdery oxidized ores and brown iron-ore siftings. The over-all amount of siderite ores used in this process is not large, about 15 percent of the total carbonate ore resources.

#### Use of Uncalcined Carbonate Ores

During the period 1945 to 1946, the Chelvybinsk Metallurgical Plant utilized many thousands of tons of uncalcined Bakal carbonate iron ores as a subcharge for Bakal oxide ores and produced an excellent grade of steel. The smelting process was better than expected. According to data made available by the Bakal Ore-Preparing Combine, one ton of agglomerate is four times more expensive and one ton of calcined ore is seven times more expensive than the crude iron ore in pieces. This is definite proof of the economy which can be realized by smelting raw siderite ores.

#### Conclusion

1. Bakal deposits are characterized by vertical zonality both for oxidized and carbonate ores. The oxidized ores are replaced by siderite ores as the depth increases. This change-over is rather sharply defined, and it can be stated generally that at the 600-meter level one square meter of ore contains 25-30 percent siderite. This content increases to 100 percent at a still lower level.
2. The above characteristic should not be disregarded in planning exploitation of the Bakal deposits. It is necessary to utilize all of the siderite which can be obtained from any depth where oxidized ores are found together with siderite ores.
3. With the data available today it is possible to conclude that oxidized ores comprise only 50 percent of the Bakal deposits.

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